1982 ✓

floods and flood control

A flood is the inundation of normally dry land resulting from the rising and overflowing of a body of water. The effects of floods, both beneficial and destructive, have been recorded for at least 5,000 years, serving as the basis for myth, religious beliefs, and scientific study.

The most familiar flood story is that in the Book of Genesis. The event upon which this Old Testament tale is based may have occurred about 3000 BC, when the Euphrates River inundated a vast area, including Ur in Southern Mesopotamia. According to the Bible, the flood resulted from 40 days of continual rain, producing high water that lasted 150 days and flood depths in excess of 15 cubits (7.5 m/25 ft). (See DELUGE.)

The benefits of regular flooding were appreciated in ancient Egypt, where the floodwaters of the Nile brought fertile silt and much-needed water to the fields each year. The pharaohs, recognizing that flooding meant prosperity, levied higher taxes after floods. Accordingly, the oldest records of stream levels are from the Nile. Flooding has probably been more intensely studied and more carefully recorded than any other natural phenomenon since the birth of civilization.

COASTAL FLOODS

Floods are classified in various ways for many special purposes. In the most useful general classifications, coastal flooding of lakes and oceans is distinguished from river flooding. Coastal flooding can be caused by high, wind-generated WATER WAVES, exceptionally high tides, SUBSIDENCE of coastal areas, and TSUNAMI (seismic sea waves). Coastal flooding is of special concern because, in many countries, population is concentrated along coastlines. For example, U.S. coastal counties--those bordering oceans or the Great Lakes--contained over 50% of the population in the early 1990s.

Although exceptionally high tides rarely produce serious and widespread damage on their own, they may significantly increase the hazard of flooding in combination with even moderately severe storms. Hurricanes and major storms produce most coastal floods (see HURRICANE AND TYPHOON). In 1970 a major storm (cyclone) in the Bay of Bengal produced heavy seas that inundated coastal regions of East Pakistan (now Bangladesh), killing some 200,000 people. Wind-generated waves well over 30 m (100 ft) in height have been observed in the open ocean. Fortunately, these huge waves usually diminish in size before reaching coastlines. On the other hand, tsunamis, caused by an EARTHQUAKE, LANDSLIDE, and volcanic eruptions, are low (less than a meter high) in the open ocean. They travel at speeds up to 800 km/h (500 mph), however, and grow higher as they near land; tsunamis 18 to 30 m (60-100 ft) high are not uncommon. Tsunamis occur most often in the Pacific Ocean and have taken many lives in Japan. One of the most spectacular, well-documented tsunamis of recent times occurred at Lituya Bay, Alaska, in 1958. A minor earthquake there caused a rockfall into the sea, producing a 60-m (200-ft) wave that destroyed vegetation, including heavy timber, at heights of as much as 520 m (1,700 ft) above sea level.

RIVER FLOODS

River flooding results from a variety of causes. Natural causes include rain, snowmelt, and ice jams (see ICE, RIVER AND STREAM, LAKE). The rate at which soil can absorb water decreases with continuous wetting. The longer a rainstorm lasts, or the greater the rate of precipitation, the higher the percentage of rain that will flow across ground as runoff and enter stream channels.

Floods on major rivers, such as the Mississippi and the Missouri, result from prolonged periods of precipitation over broad regions. This was the case in 1993, when torrential rainfall that began in April continued into May, June, and July, flooding 6.5 million hectares (16 million acres) in Iowa, Illinois, Minnesota, Missouri, Wisconsin, South Dakota, Nebraska, and Kansas. Dozens of deaths and damage well over $10 billion dollars resulted as flood levels rose to record heights and many levees broke.

Cloudburst floods are caused by extremely intense rainfall (23 cm/10 in or more an hour), but they are short-lived, rarely continuing for more than a few hours at a given location. They tend to be somewhat more common in mountainous areas, where steep slopes cause water to travel at high speeds, thus eroding and carrying away natural and artificial debris. These floods often occur rapidly and with little warning--hence the name FLASH FLOOD.

Floods that result from snowmelt and ice jams are especially dangerous because they are not necessarily preceded by heavy precipitation. Even moderate amounts of warm rain falling on a snowpack, particularly if the

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ground beneath the snow is frozen and unable to absorb the moisture, can cause severe flooding. Such was the case in New England and adjacent states in March 1936, when snowmelt equivalent to 25-75 cm (10-30 in) of rain occurred. Slabs of ice constricted river channels and plugged bridge openings; when the flood was over, 107 people had lost their lives, and damage estimated at $270 million had been done.

The actions of humans may also cause floods. In the most obvious case, floods result from failure of artificial structures such as dams. Dams usually fail because of poor design or siting, geologic hazards such as earthquakes and landslides, or simply old age. One of the most devastating dam failures in the United States occurred in February 1972 at Buffalo Creek in Logan County, W.Va. A dam used to impound coal-mining wastes, as well as water, completely collapsed after three days of rain, causing a 3-hour flood that took 118 lives and did $65 million in damages. Failure of other structures--aqueducts, debris catchment basins, and weirs, for example--also causes floods.

Other artificial causes include the constriction of streams by engineering projects such as landfills; removal of vegetation, which accelerates the rate of runoff; and paving and construction, which reduce the land's capacity to absorb rainfall. Even the installation of storm sewers can increase flood hazards, by augmenting streamflow.

WARNING SYSTEMS

Deaths caused by flooding in the United States have averaged about 200 annually since 1970, and property losses have reached over $4 billion per year. Losses would be far higher were it not for the 50 state offices of the National Weather Service's River and Flood Forecasting Service, which issue flood forecasts and warnings to the general public. Flood forecasts are based on meteorological data and forecasts, upstream information, and estimates (based on previous experience and analysis) of how a particular watershed will respond to precipitation.

The U.S. Coast and Geodetic Survey, with the cooperation of the armed forces and the Federal Aviation Agency, maintains the Seismic Sea Wave Warning System, a network of seismic- and tide-monitoring stations rimming the Pacific Ocean. The warnings, made available to all nations, have proved effective in saving lives and reducing property loss.

Flood frequency analyses are performed by hydrologists, engineers, and planners, using records of past streamflow to estimate the probability of occurrence of floods of various sizes. For example, if a flood of a particular size has a probability of one chance in one hundred of being equaled or exceeded each year, it is said to be a "100-year flood."

FLOOD CONTROL

Coastal flooding is an almost insoluble problem. Even where major flooding is practically an annual occurrence, the need for land far outweighs the dangers of flood. For example, much of the agricultural land in Bangladesh is a vast, low-lying plain formed by the deltas of three great rivers. If the yearly MONSOON brings heavy rains, or a CYCLONE or hurricane raises water levels, the plain is inundated, and inhabitants are swept away. In the Netherlands after the catastrophic storm of 1953, which destroyed dikes and flooded POLDER lands, the Dutch devised the DELTA PLAN to protect the most vulnerable areas of the southern coast. Completed in 1985, the project consists of a 9-km (5.6 mi) length of movable steel gates suspended between 66 huge concrete pillars. The gates hang above the ocean and will be lowered only when a sea surge is anticipated. The THAMES river barri er is another, smaller surge barrier; erected on the river just below London, it was completed in 1982.

Two different and at times competing approaches to flood-hazard reduction are used in attempting to prevent or reduce damage due to flooding: structural and nonstructural. Advocates of the structural approach rely on dams and reservoirs, levees or dikes, modification of stream channels, flood-diversion systems, and treatment of watersheds. Flood-control dams impound water at times of flood to mitigate downstream hazard; then, after the threat subsides, water is slowly released. Artificial levees raise the height of stream banks, thus reducing the likelihood of flooding. Straightening of channels to allow floodwaters to flow faster and therefore shallower is yet another method. In some places, floodwaters are diverted into previously prepared holding basins to reduce the flood crest downstream. Another technique diminishes the amount of water entering streams by reforesting the watershed and by detaining runoff high in the headwaters of a river.

In addition to noting that the cost of flood-control structures often exceeds the value of the property being protected, critics point out that dams often increase flood hazards by luring residents closer to the stream than is prudent, so that when a dam fails the flood is more severe. Artificial levees tend to move the hazard upstream or downstream,

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and levee failure can be extremely serious, as it was in the U.S. Midwest in 1993. Channel straightening is often temporary. For example, new bends have developed along several hundred kilometers of the Mississippi River since the 1930s, when the U.S. Army Corps of Engineers began extensive channel improvements.

Advocates of the nonstructural approach prefer using zoning, subdivision regulations, and public acquisition to prevent new building in a FLOODPLAIN. They encourage using these lands for compatible purposes, such as for agriculture and parks. For areas of existing development, early-warning systems and flood insurance are prescribed.

Critics of the nonstructural approach agree that avoidance of flood-prone areas is desirable. They point out, however, that many major cities were sited adjacent to bodies of water for purposes of transportation, power generation, and water supply, and that it is economically unfeasible to abandon these metropolitan areas. Recent trends in flood control have been toward the use of both approaches, as nonstructural methods have gained greater recognition. The National Flood Insurance Act, enacted (1968) by the U.S. Congress, provides affordable flood insurance to the owners of buildings in communities that participate in land-use programs to reduce flood damage risks. Risks can be lessened, for example, by restricting new building in areas that are known to be flood prone. In the early 1990s, almost every eligible U.S. community--those whose precincts lie within flood prone areas and that have significant development--was participating in the program, with almost two-and-a-half million individual flood insurance policies in force.

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